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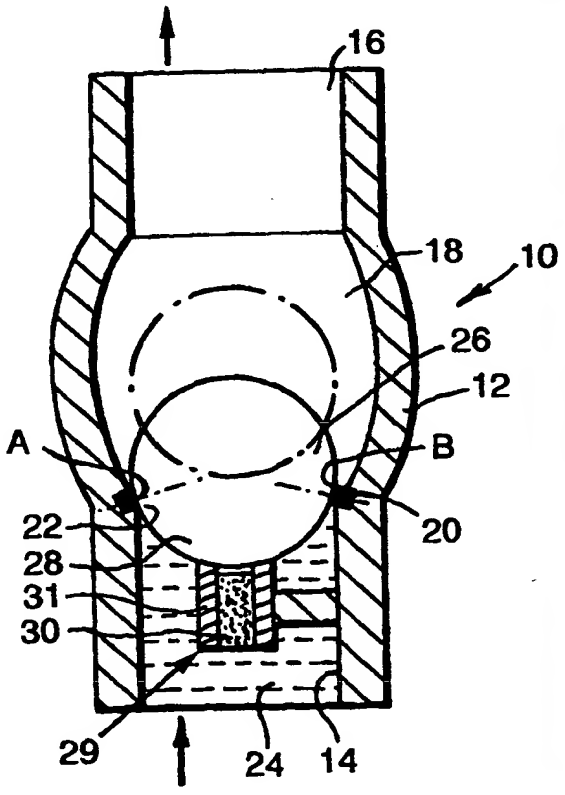
(54) Title: VALVE MECHANISM

(57) Abstract

The invention provides a pressure–opened magnetically–closed valve mechanism for fluids, comprising a housing (12) provided with at least one inlet (14), at least one outlet (16) and at least one chamber (18) connecting therebetween, the chamber (18) being provided with an elastically deformable sealing ring (20) defining an opening (22) for the passage of fluid (24) therethrough, a sealing body (26) positioned within the chamber (18) and moveable between a first, sealing position and a second position, the body (26) having at least one circular cross–sectional area (28) sized to be wedged in the opening (22) to effect the sealing thereof and to prevent the passage of fluid through the chamber (18), wherein in the first position the body (26) exerts a lateral force against the ring (20) greater than the force exerted by the body against the ring (20) in the direction facing the inlet (14), and wherein in the second position the sealing body (26) is sufficiently distanced from the seal ring (20) to allow free fluid flow from the inlet (14) to the outlet (16), and a permanent magnet component (29) and a ferromagnetic body component, one of the components (29) being rigidly mounted in the chamber between the inlet (14) and the seal ring (20), and the remaining component being a part of the sealing body (26), the permanent magnet component (29) comprising a magnetic body (30) flanked by a pair of ferromagnetic plates (31), ends of each of the plates (31) extending beyond an end of the magnetic body (30) to create an air space therebetween, whereby a magnetic flux flows through the magnetic body (30) and through the ends of the ferromagnetic plates (31) to securely hold the ferromagnetic body component (26), when brought into contact therewith, and to thereby retain the sealing body (26) in the first position until the application of a predetermined break pressure by the fluid against the sealing body (26), whereupon the sealing body is displaced to the second position.



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VALVE MECHANISM

Technical Field

The present invention relates to a valve mechanism. More particularly, the invention provides a pressure-opened magnetically-closed mechanism which can be used as part of a pressure control valve, as part of a safety valve or of a flowmeter.

Background Art

Known valve mechanisms are operated by hand, foot, mechanically by contact with a machine element, by spring, solenoid, and hydraulic or pneumatic pressure either full line pressure or pilot pressure. Many known valves are arranged to open and close using two different actuating sources. A common example is the solenoid open, spring close valve.

Pressure operated valves are usually opened by fluid pressure acting against a sealing body and overcoming the resistance of a strong coil compression spring. Such valves may be of the directional control type, typically 4 way valves, or more simply 2-way on-off valves such as the safety relief valve. The latter type can be used for crude pressure control, but for more satisfactory pressure control, more complex valves, often using pilot fluid pressure are used - these can be of the counterbalance, diverting, sequence, or unloading types. All such valves use coil compression springs as their central control element.

One of the drawbacks of prior-art pressure-operated spring-return valves lies in the high flow resistance encountered in the open position, due to spring pressure urging the mechanism towards the closed position.

Pressure opening valves having a compression spring as their central component are usually provided with adjustment means to allow changes in the valve break point. In many applications the provision of such adjustment is advantageous or even essential. However adjustment after installation may be carried out by unauthorized or unskilled persons, and the results of a pressure release valve not opening as intended can be disastrous. Moreover, there are many applications where no field adjustment is required, and thus is not provided, and where the possibility of tampering with a pressure-release setting is best completely avoided. One example of such an application is in a flowmeter having multiple

internal flow paths which come into use in response to changes in flow volume or pressure. Valves having a fixed value for valve opening not only avoid the possibility of maladjustment, intentional or not, but are also more compact and cheaper to manufacture. The present invention provides a valve mechanism of this type. In U.S. Patent 5,576,486, and in Israel Patent 107 848, the present inventor has disclosed an electronic flowmeter. The flowmeter includes among its various components a permanent magnet which at low fluid pressure locks a valve ball on a lower seal, to hold the ball, so that the valve is in its closed position (Figure 2, and claim 3). The valve ball contacts the lower seal at about half the ball diameter. For example, using a 32 mm diameter ball, seal contact is made on a ring of approximately 16 mm diameter.

Such a configuration provides very little seal force leverage, and so a magnetic force of about 10 Newtons is required to apply a sealing force of about 12 Newtons to compress the flexible seal element. Further, one of the possible drawbacks of the disclosed flowmeter was the possibility of a solid foreign object being lodged on top of the magnet which could prevent effective closure of the valve ball.

When installed, said flowmeter is always oriented in a manner where the steel ball is vertically above said magnet, thus ensuring that when fluid pressure drops below a threshold level, the sealing body will be within range of the magnet. However, if the described items were to be used for other purposes, it would be advantageous to allow for possible installation orientation in any direction. For example, if installation were such that the steel ball was positioned below the magnet, once separated from the magnet the magnet would be unable to re-attract the ball with sufficient force to lift the ball against the force of gravity. The reason for this lies in the very sharp drop in magnetic force exerted by any type of magnet as separation distance increases between itself and the attracted ferrous body.

It has now been found that by effecting further improvements to these elements to give improved sealing in the closed position and improved flow in the open position, a novel pressure-opened valve mechanism is obtained, which has application in devices additional to electronic flowmeters.

Disclosure of the Invention

It is therefore one of the objects of the present invention to obviate the disadvantages of prior art valve mechanisms and to provide a device which offers increased closing reliability and very low flow resistance when open.

It is a further object of the present invention to provide a pressure-opening valve which cannot be maladjusted in service and which is cheap to manufacture.

The present invention achieves the above objects by providing a pressure-opened magnetically-closed valve mechanism for fluids, comprising:

a) a housing provided with at least one inlet, at least one outlet and at least one chamber connecting therebetween, said chamber being provided with an elastically deformable sealing ring defining an opening for the passage of fluid therethrough;

b) a sealing body positioned within said chamber and moveable between a first, sealing position and a second position, said body having at least one circular cross-sectional area sized to be wedged in said opening to effect the sealing thereof and to prevent the passage of fluid through said chamber, wherein in said first position said body exerts a lateral force against said ring greater than the force exerted by said body against said ring in the direction facing said inlet, and wherein in said second position said sealing body is sufficiently distanced from said seal ring to allow free fluid flow from said inlet to said outlet; and

c) a permanent magnet component and a ferromagnetic body component, one of said components being rigidly mounted in said chamber between said inlet and said seal ring, and the remaining component being a part of said sealing body, said permanent magnet component comprising a magnetic body flanked by a pair of ferromagnetic plates, ends of each of said plates extending beyond an end of said magnetic body to create an air space therebetween, whereby a magnetic flux flows through said magnetic body and through the ends of said ferromagnetic plates to securely hold said ferromagnetic body component, when brought into contact therewith, and to thereby retain said sealing body in said first position until the application of a predetermined break pressure by said fluid against said sealing body, whereupon said sealing body is displaced to said second position.

Description of Preferred Embodiments

In a preferred embodiment of the present invention there is provided a pressure-opened magnetically-closed valve mechanism for fluids wherein the great-circle arc on said at least semi-spherical sealing body, defined by two diametrically opposite points of contact of said body and said ring subtends an angle of at least 150 degrees.

In a most preferred embodiment of the present invention there is provided a pressure-opened magnetically-closed valve mechanism for fluids wherein the great-circle arc on said at least semi-spherical body, defined by two diametrically opposite points of contact of said body and said ring subtends an angle of about 180 degrees.

In one of its embodiments there is provided a flowmeter wherein flow through at least one of its internal passages is controlled by a pressure-opened magnetically-closed valve mechanism of the type described above.

Yet further embodiments of the invention will be described hereinafter.

It will thus be realized that the novel mechanism of the present invention serves to provide fixed valve opening pressure which will not change substantially over the life of the device. The mechanism is reliable, low in manufacturing cost, and the only conceivable servicing required will be to replace the seal element when needed. By using a seal ring suitable for extended service in the fluid being controlled, such servicing may not be required over the lifetime of the device it serves.

Furthermore, in the preferred embodiments of the present invention the force exerted on said sealing element is predominantly lateral and predetermined by designed, thereby limiting wear on said seal element.

Said sealing ring can be of different configurations, having round, half-round, oval or even square cross-section.

While break pressure is not adjustable by the user, such setting can be set at a required value by the manufacturer by installing an appropriate magnet type and size, and by choosing a suitable size area of the sealing body for exposure to line pressure.

The invention will now be described in connection with certain preferred embodiments with reference to the following illustrative figures so that it may be more fully understood.

Brief Description of the Drawings

With specific reference now to the figures in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

In the drawings:

Figure 1 is a sectional elevation of a preferred embodiment of the valve mechanism according to the invention;

Figure 2 is a sectional elevation of an embodiment having a 180 degree sealing ring contact arc;

Figure 3 is a sectional elevation of a mechanism where the magnet is a part of the sealing body;

Figure 4 is a sectional elevation of an embodiment including a sealing body return spring ;

Figure 5 is a sectional elevation of an embodiment having improved flow characteristics;

Figure 6 is a sectional elevation of an embodiment including stop means;

Figure 7 is a sectioned detail of a flowmeter utilizing a mechanism similar to that described with reference to Figure1;

Figure 8 is a perspective view of the magnetic and a ferromagnetic component which are used in the embodiment described with reference to Figure 1; and

Figure 9 is a cross-sectional elevation of a valve, shown in its closed position, made according to the present invention.

There is seen in Figure 1 a pressure-opened magnetically-closed valve mechanism 10 for fluids.

A housing 12 is provided with an inlet 14, an outlet 16 and a chamber 18 connecting therebetween. The chamber 18 is provided with an elastically deformable sealing ring 20 defining an opening 22 for the passage of fluid 24 therethrough.

A sealing body 26 is positioned within chamber 18 and is moveable between a first, closed, sealing position as shown and a second, open position, broken lines.

In the present embodiment the body 26 is a steel sphere. One of its circular cross-sectional areas is sized to be wedged in opening 22 and when in the first position effects the sealing thereof, and prevents the passage of fluid 24 through the chamber 18. In such first position body 26 exerts a lateral force against sealing ring 20 greater than the force exerted against ring 20 in the direction facing inlet 14. When in the second position the sealing body 26 is sufficiently distanced from the sealing ring 20 to allow free fluid flow from inlet 14 to outlet 16.

Advantageously, as shown in the present embodiment, the sealing body 26 in chamber 18 is drawn towards the first position from second position under the force of gravity. This eliminates the need for a return device, and also utilizes the weight of the sealing body 26 to add to sealing force.

While in the present embodiment the sealing body 26 is a sphere, in all embodiments the sealing body is provided with an at least semi-spherical section 28 facing the inlet 14. The sphere has the advantage of eliminating possible orientation problems.

The great-circle arc on sealing body 26, defined by two diametrically opposite points of contact A,B, of body 26 and sealing ring 20 subtends an angle of about 150 degrees. Thus a substantial wedging action is obtained, and the operation of magnetic force, which will be explained, acting to compress the sealing ring 20 is about twice the axial force applied to the sealing body 26.

The sealing body 26 shown comprises a ferromagnetic component. It is attracted to a permanent magnet component 29 which is rigidly mounted in the chamber between inlet 14 and sealing ring 20.

The permanent magnet component 29 comprising a magnetic body 30 flanked by a pair of ferromagnetic plates 31 (as will be described in greater detail with reference to Figure 8 and with different reference numbers) attracts to, and retains the sealing body 26 in the first position. The application of a predetermined break pressure by fluid 24 against sealing body 26 overcomes the magnetic attraction and displace the sealing body 26 to its second position to allow free fluid flow. Even at full flow rates, in a typical application the pressure drop across the mechanism is only 0.03 to 0.20 bar. Pressure drop can be further reduced by changing the shape of the sealing body, as will be shown in Figure 5.

With reference to the rest of the figures, similar reference numerals have been used to identify similar parts.

Referring now to Figure 2, there is seen a further embodiment of pressure-opened magnetically-closed valve mechanism 32 for fluids.

The great-circle arc C,D on the sealing body 34, defined by two diametrically opposite points of contact E,F of sealing body 34 and sealing ring 36 subtends an angle of about 180 degrees. The sealing ring 36 is an O-ring which expands diametrically on entry therein of the sealing body 34. Entrance of the sealing body 34 into the sealing ring 36 requires only a small force which is easily provided by the magnetic component 30.

Figure 3 illustrates a further embodiment of a pressure-opened magnetically-closed valve mechanism 38. The permanent magnet component 30, described in detail with reference to Figure 8, is mounted within the sealing body 40. The sealing body 40 can be made of a plastic or any other non-ferromagnetic material and is slidably suspended in chamber 44.

A ferromagnetic body component 42 is rigidly mounted between inlet 46 and a washer-like sealing ring 48. The ferromagnetic body component 42 is suspended in the inlet flow path on spider legs 50 to allow free fluid passage when the sealing body 40 is in the second, open position.

The sealing body 40 is advantageously provided with a piston-like guide means 50 delimiting the displacement of body 40 between the first and second position, in order to ensure that the sealing body 40 is correctly aligned when in the first position. The aligning stem 52 is a loose fit in its guideway 54 to prevent jamming and to allow a degree of self-alignment at the first, closed position.

Although in the present embodiment the magnetic components are transposed, operation of the valve mechanism 38 is as has been described with reference to Figure 1.

Seen in Figure 4 is an embodiment of a pressure-opened magnetically-closed valve mechanism 56 for fluids further provided with weak spring means; the present embodiment can be used installed in any orientation. A light compression spring 58 urges the sealing body 60 towards the first position. When the sealing body 60 is in its second, open position, and fluid pressure is low, the spring 58 moves the sealing body 60 closer towards the sealing ring 62. On arrival to proximity of the sealing ring 62, the attractive force generated by the magnetic circuit increases sharply, and the sealing body 60 is pulled tightly against the sealing ring 62 to close the valve. When fluid pressure rises and exerts an increased force on the sealing body 60, the sealing body 60 moves to compress the spring 58 and to reach its second, open position.

It will be understood that the relatively light spring 58 functions merely to move the sealing body 60 against light fluid pressure, and seals in conjunction with the force of the magnetic circuit. This is in contradistinction to prior art valves where a heavy compression spring is intended to alone resist high fluid pressure.

Referring now to Figure 5, there is depicted a pressure-opened magnetically-closed valve mechanism 64 having improved flow characteristics in the open position.

The sealing body 66 is provided with surfaces configured to enhance streamlined hydrodynamic flow. The sphere used as a sealing body 26 described with reference to Figure 1 when subjected to fluid flow causes boundary layer separation, whether the wake is wide, as with laminar flow, or is narrow as when flow is turbulent.

The sealing body 60 has guide means 50 similar to that seen previously in Figure 3.

Figure 6 shows a valve mechanism 67 installed in a horizontal orientation yet does not require a return spring as does the embodiment described with reference to Figure 4. The mechanism 67 is shown in its open position.

Stop means 68 are mounted in the chamber 18 which prevent the sealing body 69 from completely moving out of the range of attraction of the permanent

magnet component 30. Thus when pressure drops, the magnetic circuit XY exerts sufficient force to move the sealing body 69 towards, and then into the first sealing position. When the sealing body 69 is in the second position, as shown, valve opening is sufficient to allow fluid flow at moderate flow resistance.

Guide means (not shown) maintain the sealing body 69 on the valve center axis.

Figure 7 illustrates a detail of a flowmeter 70, similar to that described in U.S. Patent 5,576,486. The flow through an internal passage 71 which acts as a bypass to the main flow passage 72, is controlled by a pressure-opened magnetically-closed valve mechanism 74 for fluids, similar to that described with reference to Figure 1 in the present application. The flowmeter shown here is provided with improved sealing in the main-flow passage. The opposite points of contact of the sealing body 78 and the sealing ring 76 have a curvature displacement of 160 degrees from each other. Thus a substantial wedging action is obtained, and the force acting to compress the sealing ring 76 is about twice the axial force applied to the sealing body 78, which is a steel ball. Furthermore, an air gap 80 near the magnet center prevents any solid foreign body from disturbing effective sealing.

Seen in Figure 8 is a permanent magnet component 30 comprising a magnetic body 82 flanked by a pair of ferromagnetic plates 84. The ends 86 of each plate 84 extend beyond an end of the magnetic body 82 to create an air space therebetween. A magnetic flux 88 flows through magnetic body 82 and through the ends 86 of ferromagnetic plates 84 to securely hold a ferromagnetic body component 90.

The air space as mentioned allows clearance for a foreign solid body; said space also provides additional magnetic attraction. This is illustrated by the following example:

Attracted body: 25 dia steel ball

Steel plates flanking the magnet: 2.7 thick, 13.1 long

Air gap, ball to magnet:	Attraction force:
zero	3.4 kg
1 mm	4.2 kg
2 mm	2.3 kg

The ends of the ferromagnetic plates 84 define and delimit a concave space complementary to the curvature of the surface of that part of the sealing body which on assembly faces the valve inlet.

A magnetic flux flows through the magnetic body and through the ends of ferromagnetic plates at the sides of the magnet to securely hold the sealing body when brought into contact therewith

Figure 9 shows a valve 92 in its second, closed position. The first part 96 of a sealing body forms part of a streamlined form when the valve 92 is in its first, open position and fluid flows through the valve outlet 98. The first part 96 also contains a permanent magnet 100. The second part 102 of the streamlined form is rigidly mounted on fins 104 in the valve chamber 106. The two parts 96, 102 are connected by a piston-like stem 108 and a loose-fitting guideway 110. A light compression spring 112 urges the first part 102 into magnetic range of the ferromagnetic body 114, rigidly mounted in the valve inlet 116. An elastically deformable sealing ring 118 contacts the first part 96 when the first part 96 is in the closed position shown.

On fluid pressure rise, the fluid pushes the first part 96 to within the proximity of the second part 102, breaks the magnetic circuit, and compresses the spring 112. Fluid then flows through inlet 116, by the side of the ferromagnetic body 114, around the two parts 96, 102, between fins 104 and through outlet 98. The valve 92 can be made in various sizes with little change in configuration..

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrative embodiments and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

WHAT IS CLAIMED IS:

1. A pressure-opened magnetically-closed valve mechanism for fluids, comprising:

a) a housing provided with at least one inlet, at least one outlet and at least one chamber connecting therebetween, said chamber being provided with an elastically deformable sealing ring defining an opening for the passage of fluid therethrough;

b) a sealing body positioned within said chamber and moveable between a first, sealing position and a second position, said body having at least one circular cross-sectional area sized to be wedged in said opening to effect the sealing thereof and to prevent the passage of fluid through said chamber, wherein in said first position said body exerts a lateral force against said ring greater than the force exerted by said body against said ring in the direction facing said inlet, and wherein in said second position said sealing body is sufficiently distanced from said seal ring to allow free fluid flow from said inlet to said outlet; and

c) a permanent magnet component and a ferromagnetic body component, one of said components being rigidly mounted in said chamber between said inlet and said seal ring, and the remaining component being a part of said sealing body, said permanent magnet component comprising a magnetic body flanked by a pair of ferromagnetic plates, ends of each of said plates extending beyond an end of said magnetic body to create an air space therebetween, whereby a magnetic flux flows through said magnetic body and through the ends of said ferromagnetic plates to securely hold said ferromagnetic body component, when brought into contact therewith, and to thereby retain said sealing body in said first position until the application of a predetermined break pressure by said fluid against said sealing body, whereupon said sealing body is displaced to said second position.

2. A pressure-opened magnetically-closed valve mechanism for fluids according to claim 1, wherein said sealing body is provided with an at least semi-spherical section facing said inlet.

3. A pressure-opened magnetically-closed valve mechanism for fluids according to claim 2, wherein the great-circle arc on said at least semi-spherical body, defined by two diametrically opposite points of contact of said body and said ring subtends an angle of at least 150 degrees.

4. A pressure-opened magnetically-closed valve mechanism for fluids according to claim 2, wherein the great-circle arc on said at least semi-spherical body, defined by two diametrically opposite points of contact of said body and said ring subtends an angle of about 180 degrees.

5. A pressure-opened magnetically-closed valve mechanism for fluids according to claim 1, wherein said permanent magnet component is positioned within said sealing body.

6. A pressure-opened magnetically-closed valve mechanism for fluids according to claim 1, wherein said sealing body is provided with a piston-like guide means delimiting the displacement of said body between said first and said second position.

7. A pressure-opened magnetically-closed valve mechanism for fluids according to claim 1 further provided with a relatively weak spring means urging said sealing body towards said first position.

8. A pressure-opened magnetically-closed valve mechanism for fluids according to claim 1, wherein said body is provided with surfaces configured to enhance streamlined hydrodynamic flow.

9. A pressure-opened magnetically-closed valve mechanism for fluids according to claim 2, wherein said permanent magnet component is rigidly mounted in said chamber, and said ends of said plates define and delimit a concave space complementary to the curvature of the surface of said sealing body facing said inlet.

10. A pressure-opened magnetically-closed valve mechanism for fluids according to claim 1, wherein said sealing body is positioned within said chamber to be drawn to said first position from said second position under the force of gravity.

11. A pressure-opened magnetically-closed valve mechanism for fluids according to claim 1, wherein stop means mounted in said chamber prevent said sealing body from completely moving out of the range of attraction of said permanent magnet component.

12. A flowmeter wherein flow through at least one of its internal passages is controlled by a pressure-opened magnetically-closed valve mechanism for fluids according to claim 1.

Fig.1.

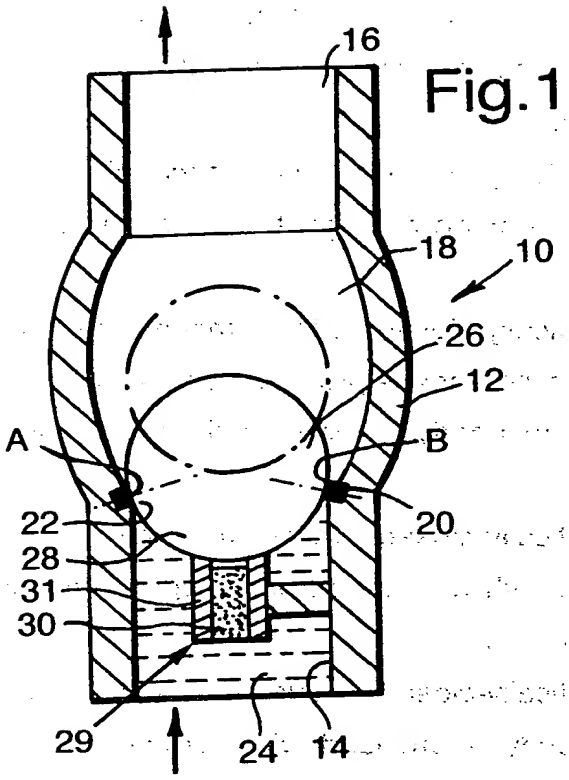


Fig.2.

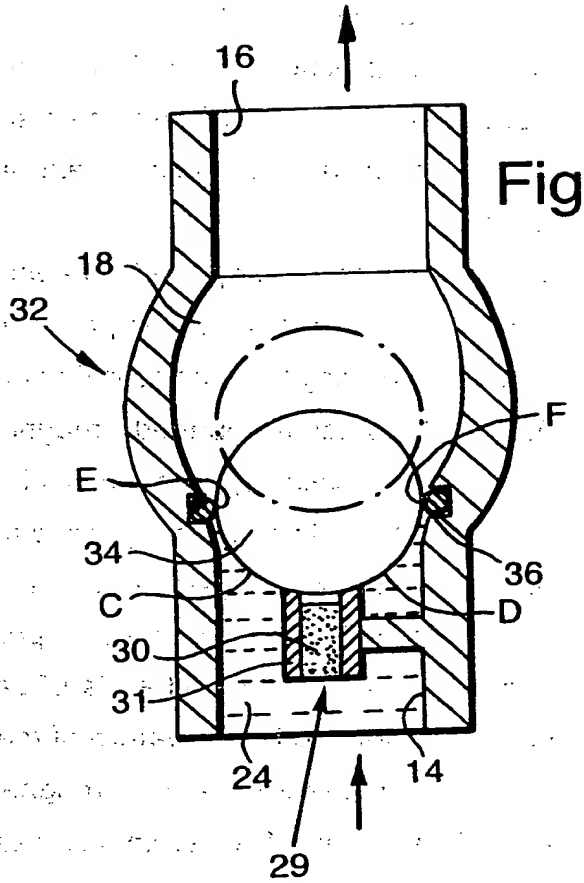
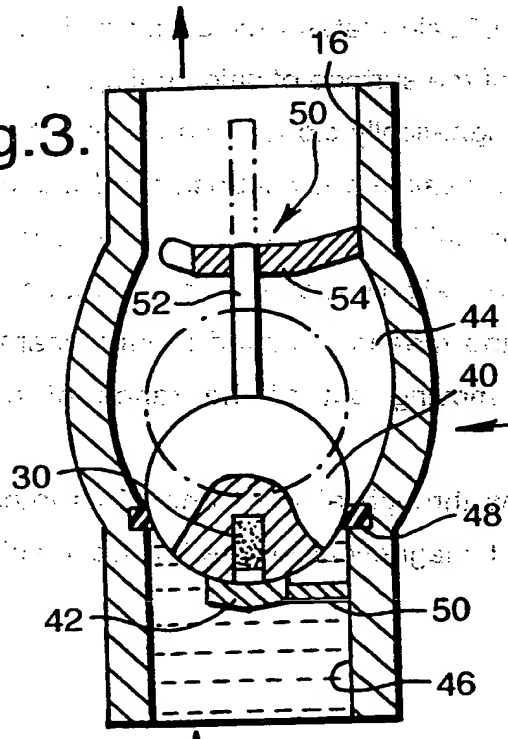


Fig.3.



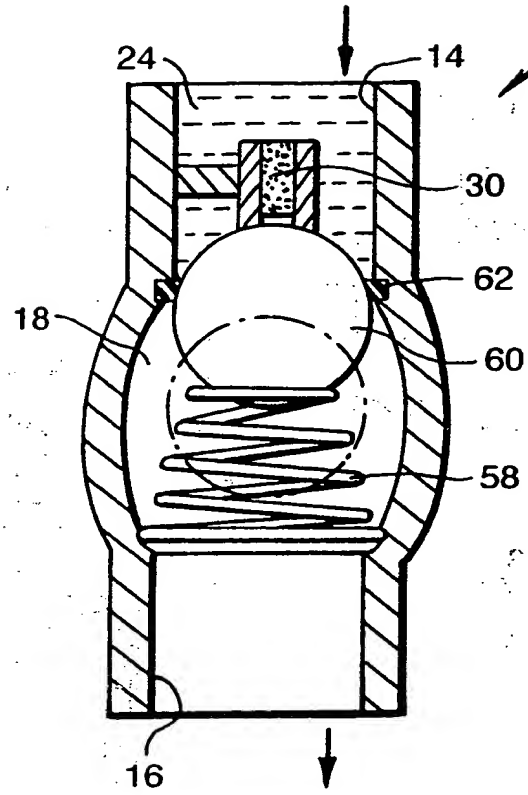


Fig.4.

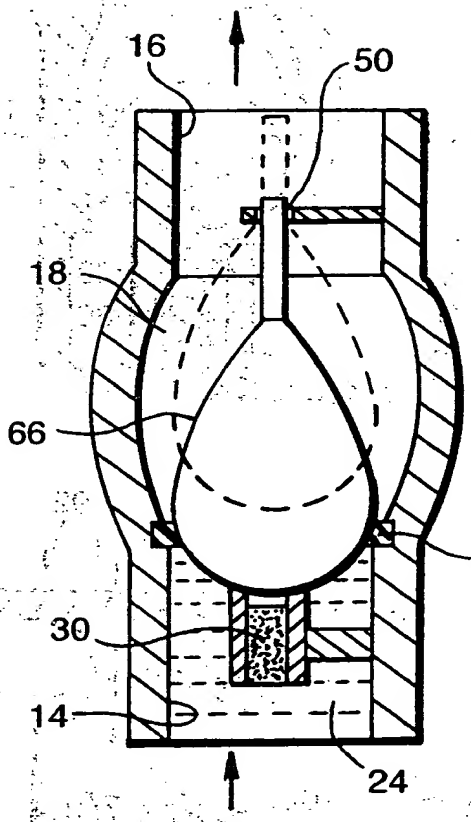


Fig.5.

Fig.6.

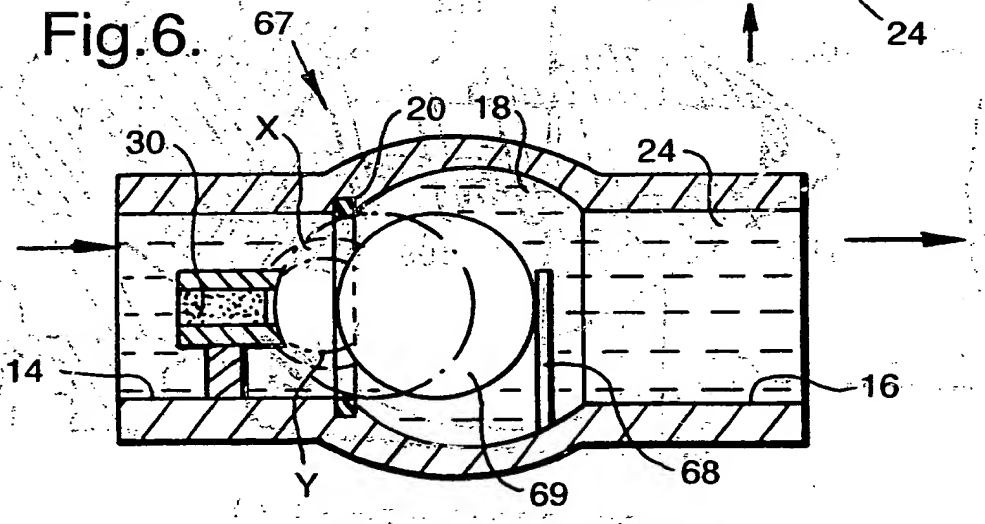


Fig.7.

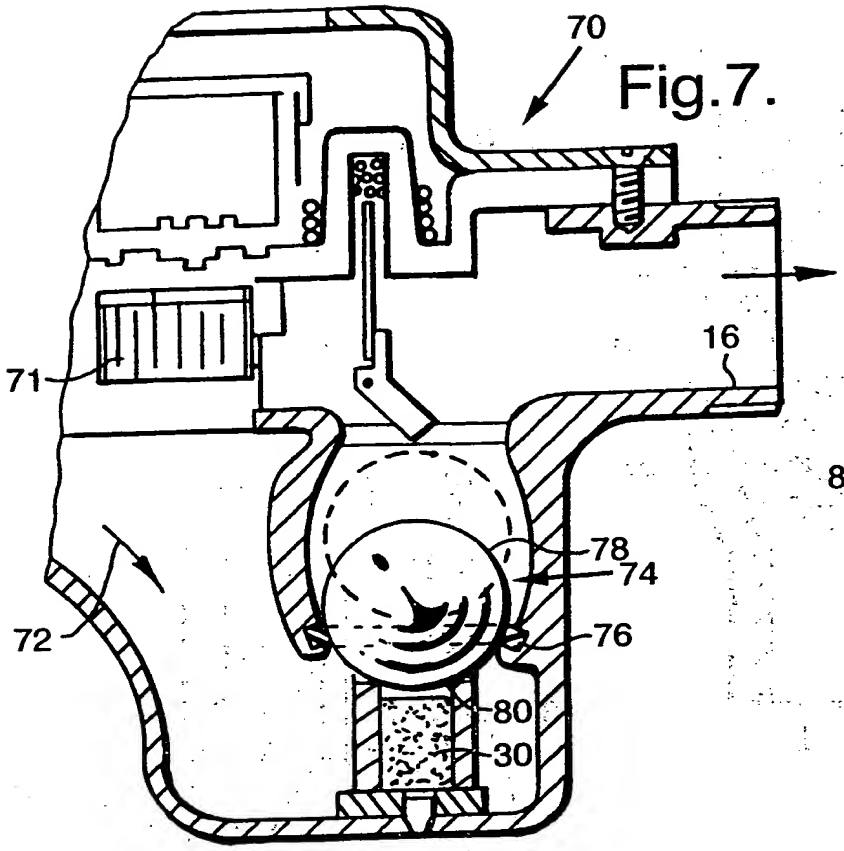


Fig.8.

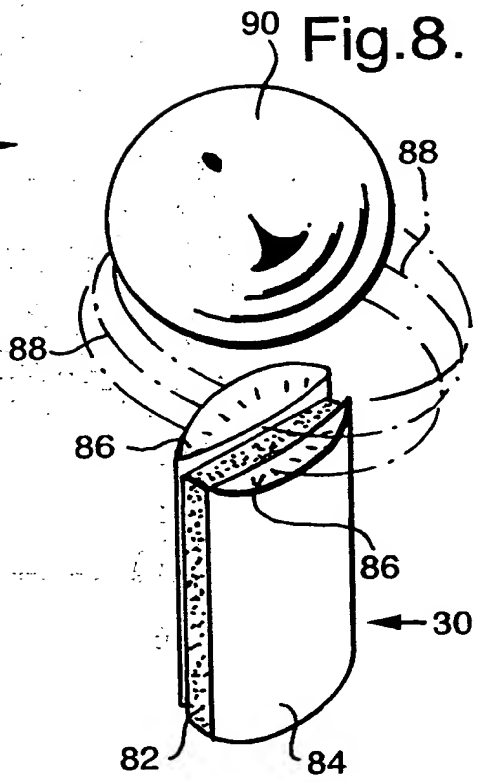
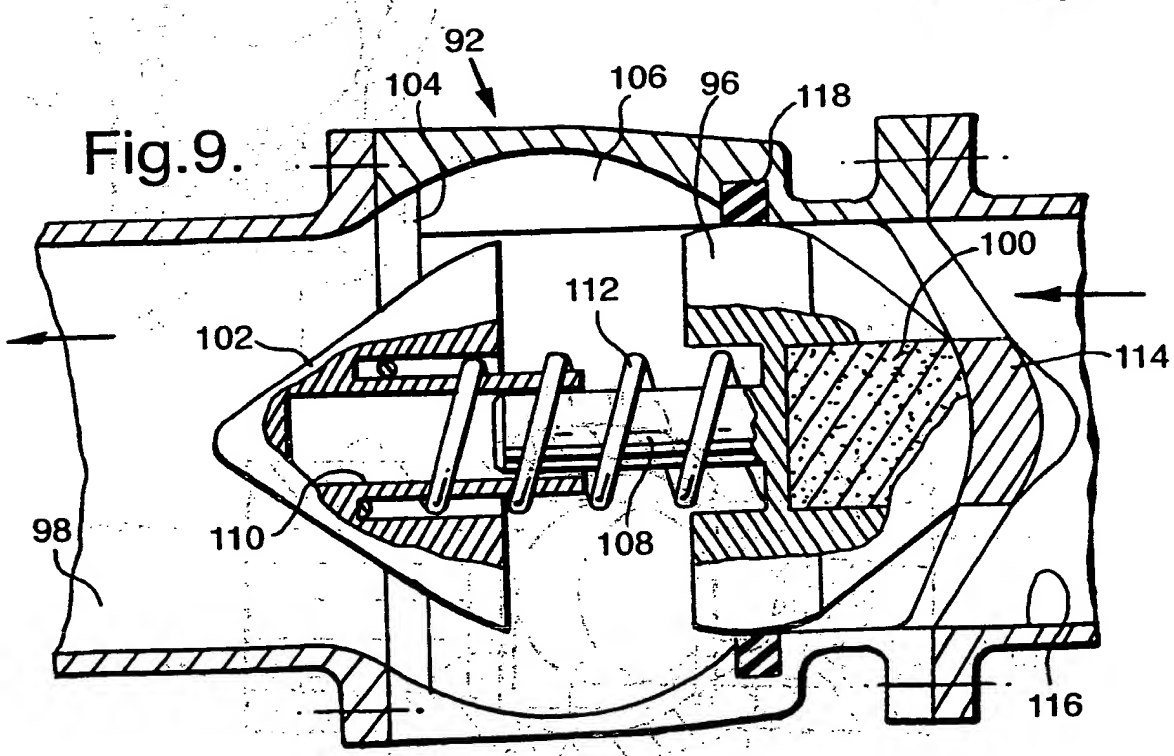


Fig.9.



INTERNATIONAL SEARCH REPORT

national Application No
PCT/IL 98/00272

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16K31/08 F16K15/04 F16K15/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F16K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	DE 941 759 C (WALTER JORDAN) 20 October 1955 see page 2, line 85-106; figure 1	1,6,8,11 2-4
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A	DE 19 31 799 A (HONSBERG) 7 January 1971 see figure 1	1,5
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
20 August 1998	03/09/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lokere, H

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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